RS AND GIS BASED INTEGRATED STUDY ON SUSTAINABLE WATER RESOURCE MANAGEMENT OF SHIKARIPURA TALUK, SHIVAMOGGA DISTRICT, KARNATAKA STATE, INDIAKARNATAKA STATE, INDIA

Final synopsis submitted to Mangalore University,

Mangalagangothri for the Award of Degree of

DOCTOR OF PHILOSOPHY

IN

MARINE GEOLOGY

By

Bhavya P

Research Scholar

Under the guidance of

Dr. H. Gangadhara Bhat

Professor

Department of Marine Geology
Mangalore University
Mangalagangotri-574 199

December 2020

Name of the Candidate	Bhavya P
Name of the Research Guide	Dr. H. Gangadhara Bhat
Department	Marine Geology
Title	" "RS AND GIS BASED INTEGRATED STUDY ON SUSTAINABLE WATER RESOURCE MANAGEMENT OF SHIKARIPURA TALUK, SHIVAMOGGA DISTRICT, KARNATAKA STATE, INDIA "
Date of Registration	04/01/2013
Registration Number and Date	MU/EXB/Ph.D./CR.38/M.G./2013-14/E.13 dated :04/01/2013

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1. Introduction

Water resources constitute mainly surface and groundwater, with rainfall being the basic source. The environmental concerns pertaining to water resources management, specifically relate to both quantity and quality issues. The main issues of concern are conservation of existing water resources and prevention of further degradation and depletion. The associated issues include rejuvenation of degraded traditional surface water bodies, enhancing the availability of water through water harvesting measures, and recharge of ground water resources. More important is the judicious and economic use of both ground and surface water for agricultural, industrial and domestic purposes. Karnataka is subjected to repetitive droughts. The national irrigation commission has identified 12 districts and 88 taluks in the state as chronically drought affected. Surface water is available in Karnataka in the form of rivers, lakes, waterfalls, reservoirs, etc. Karnataka has a water potential of about 102 km^3. Being the seventh largest state in India (area-wise), Karnataka possesses about six percent of the country's total surface water resources, which is 17 lakh million cubic metres (Mcum). Around 60% of this is provided by the west flowing rivers while the remaining comes from the east flowing rivers. Rainfall is the main source of water for the surface and ground water bodies. The amount of recharge depends upon the rate and duration of rainfall, as rain is the most essential means for replenishment of moisture in the soil water system and recharge to groundwater (Abdullahi, Gasim, & Juahir, 2015). Propensity towards increased groundwater recharge associated with the intensification of precipitation in a warming world (Jasechko & Taylor, 2015) In India, groundwater recharge is believed to be derived primarily from a continuous spell of rainfall during the monsoon season (Bhanja, et al., 2019). derived primarily from a continuous spell of rainfall during the monsoon season (Bhanja, et al., 2019).

Water being a crucial natural resource is perpetually under pressure due to increasing population, industrialization, urbanization, deforestation and changing climate condition. By the year 2020 the projected total water demand of the entire district will be 9.074 BCM against presently available utilizable water resources of 5.995 BCM. In that, demand for agriculture

sector itself will be 45% and for Power generation is 54%. The attendant challenges will be to produce more benefits in different sectors from less water by efficient use of utilizable water resources in irrigated areas, and to elevate the production level from sub-productive challenged ecosystems, like rainfed as well as water logged areas, and making use of grey water for agriculture production

Shikaripura taluk comes under southren transition zone of Shivamogga district A Comprehensive Composit Development Index (CCDI) drawn on the Nanjundappa report based on 35 indicators, covering 5 sectors like, agriculture and allied, industry, trade and finance, infrastructure(economic and social)and population charecterstic of the talukus of Western Ghat regions shows that, Shikaripura comes under "Backward (BW) taluk". Shikaripura is the third highest populated taluk of Shivamogga district, consisting the population of 2,36,418 in 2015 and the projected population in 2021 will be 2,46,301 (District Irrigation Plan (DIP), 2017). Population is distributed among the villages and the Shikaripura town accounts 1,85,350 and 52,879 respectively. The population has increased totally 11.54% compare to the 2001 census. According to the 2011 census Shikaripura consist of two towns and 176 villages among which 155 are inhabited and 21 are un-inhabited. The water availability for the Shikaripura taluk is contributed by both surface and ground water sources. Totally, 0.1496 BCM (Billion Cubic Meter) of water is available in which 0.0970 BCM and 0.0525 BCM are supplied from the various sources of surface water and ground water respectively.

Estimation of the ground water availability is carried out separately for the command and non-command area and the region with more than 20% slope is excluded from the recharge computations (District Irrigation Plan (DIP), 2017). The available water is utilizing in the multiple aspects majorly for the agricultural activities. Annually, 0.8128 BCM is required for the agricultural activities, 0.005271 BCM and 0.0000030 BCM for domestic uses and live stock respectively. The water availability from the various sources for agricultural and domestic uses are less (due to the high demand) hence the water gap in Shikaripura taluk was highest compared to the other taluks of Shivamogga district and the prediction was according to the studies for the year 2020 is also depicting the same result. So, conservation and the proper utilization of the water resource in sustainable manner is very much needed to use the available water resources in the taluk to the maximum potential in an efficient way catering to the basic needs of every living being and enhancing the livelihoods of rural population to the maximum extent thus alleviating poverty in a sustainable way without compromising the interests of future generations.

2. Study area:

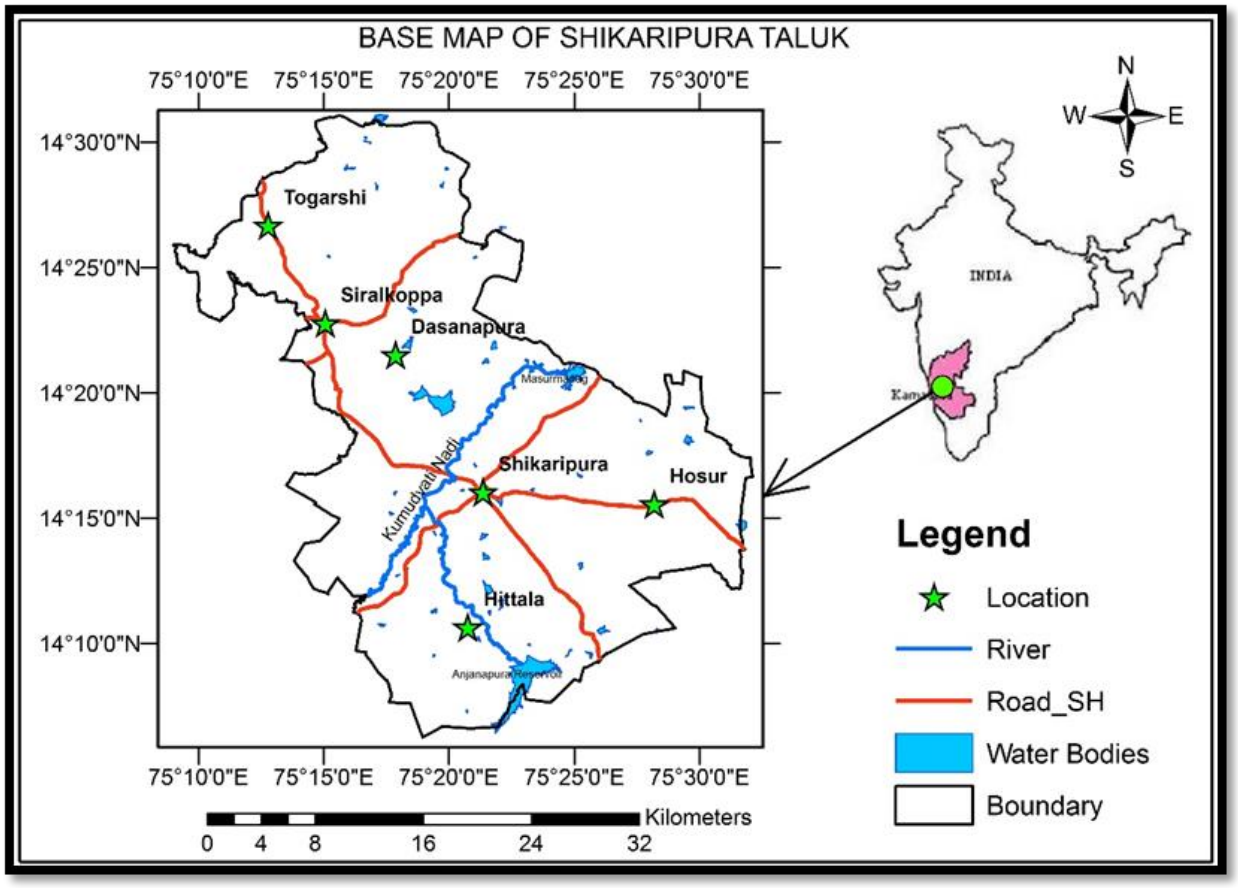

Fig: Location map of the study area.

Shikaripura is one of the taluk (sub-division) of Shivamogga district situated in between the Western Ghats and northern plane of the Karnataka state in the range of 14^0 7'–14^0 28' north latitude to 75^0 10'–75^0 30' east longitude with a total area coverage of 907.46 sq km. The majority of the study area is covered by three major watersheds viz, Kumudvati, Dandavati, and Tungab. Among them Kumudvati watershed covers 671.442 sq km, whereas Dandavati and Tungabhadra watersheds covers an area of 201.271 sq km and 34.751 sq km respectively. Shikaripura taluk lies in the eastern part of the Shivamogga district and comes under the semi-malnad region. It includes vast coverages of plain land with low lands with small hillocks with low vegetation. Geologically the study area mainy comprises of argillite and chlorite schist and mixed type of soil which is medium to fine grained permeable with high moisture content. The thickness of this type of soil ranges from 1 m to 21 m and is having the water infiltration capacity of about 0.60 cm/hour. Shikaripura gets majority of its rainfall during South West Monsoon period from the first week of June to end of September. It contributes around 69.68%

of the total rainfall with the average rainfall around an annual average rainfall of 990.4mm. Shikaripura taluk consist of 176 Villages and 45 Panchayats .

Anjanapura reservoir and Ambligolla resvoir provides drinking water to Shikaripura town and nearby areas, these are the two major reservoir in the taluk apart from this there are many tanks, dugwells and borewells which sufficiently provides water for the entire taluk. Shikaripura is one of the taluk out of few in the district which uses canal irrigation system Canal based irrigation provides water to 8027 Hectares, Tank/pond/resvoier(Govt) based irrigation provides water to 8801 Hectares and Irrigation through ground water is highest in Shikaripur taluk (9,884 Hectares).

The total quantity of water drawn (draft) is 0.252922 BCM. Highest water is drawn in Soraba taluk followed by Shikaripura taluk. These are the taluks which are draught prone taluks in the district.

As per the water budget water demand and gaps are more in Shikaripura (during 2015 it was 0.668424 BCM and during 2020 it was 0.728819 BCM). According to the survey, availability of water in 2015 was 0.09708256 BCM surface water and 0.052584100 BCM groundwater but water demand in 2015 was 0.8180908 BCM and the projected water demand was for 2020 was 0.8784864 BCM as per this water gap in 2015 was 0.668424111 BCM and the projected water gap for 2020 was 0.728819784 BCM, this once again proves that this draught prone taluk in the district needs more attention for the sustainable development of water resources management of the taluk.

3. Objectives:

The main objectives of the study are to:

- Understand the topography and drainage network characteristics by quantitative analysis.
- Study the neotectonic influence on geomorphology and on fluvial system.
- Study the influences of hydrometeorological parameters on groundwater fluctuation.
- Delineate the groundwater prospecting zone by integrating different data set, finding suitable sites and suggesting different methods for groundwater recharge.
- Study the agroforestry suitability for sustainable development of watershed management in terms of improving the socio economic condition.

Suggest suitable action plans for usage and storage of water for future generation

.4. Materials and Methodology:

4.1. Primary data:

- Survey of India Topographical maps on scale of 1:50,000 with toposheet numbers D43J2, D43J3, D43J4, D43J6, D43J7, D43J8, D43J11 and D43J12
- Landsat-8 OLI data sets of 1993, 2009, 2018 and 2019 from USGS earth explorer platform
- Multidated Indian Remote Sensing Satellite image
- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data set from USGS
- Cartosat-DEM (Digital Elevation Model) data with 15m and 30m spatial resolution from Bhuvan web platform
- Village maps (Taluk office Shikaripura)
- Google Maps
- Global positing system (GPS)

4.2. Secondary data: The dataset used in the study can be broadly classified into ancillary and field data.

1.13.1 Ancillary data

The datasets are collected in the form of printed maps/reports from the following agencies

- Survey of India Topographical maps on scale of 1:50,000 with toposheet numbers D43J2, D43J3, D43J4, D43J6, D43J7, D43J8, D43J11 and D43J12
- Landsat-7, Landsat-8 OLI data sets of 1993, 2009, 2018 and 2019 from USGS earth explorer platform
- Multidated Indian Remote Sensing Satellite images
- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data set from USGS
- Cartosat-DEM (Digital Elevation Model) data with 15m and 30m spatial resolution from Bhuvan web platform
- Village maps (Taluk office Shikaripura)

- Google images from Google Earth
- Global Positing System (GPS)

1.13.2 Secondary data

- Watershed map authorised from the Karnataka State Remote Sensing Applications Centre (KSRSAC), Bengaluru.
- Geological map from Geological Survey of India (GSI), Mangaluru.
- Soil map from Karnataka State Remote Sensing Applications Centre (KSRSAC), Mangaluru.
- Rainfall data from Karnataka State Natural Disaster Monitoring Centre (KSNDMC) Bengaluru, Water resource department, Bengaluru and taluk office, Shikaripura.
- Hydrometerological data from Karanataka State Natural Disaster Monitoring Centre, (KSNDMC), Bengaluru.
- Groundwater fluctuation level data from Groundwater Directorate District Office, Shivamogga
- Crop data from Agricultural department, Shikaripura taluk and Department of Economics and Statistics, Government of Karnataka, Bengaluru.
- Necessary Published maps, reports and literature

1.13.3 Methodology

Survey of India topographical maps on scale of 1:50,000 have been used for the extraction of the base map and thematic layers. Topographical maps are geometrically corrected, georeferenced and base map extraction has been carried out using ArcMap10.5 software and WGS (World Geodetic System) 1984 is used as the coordinate system. The digital image processing techniques such as; linear/contrast stretching, edge enhancement, filtering, PCA, band-ratioing and color compositing have been applied to digital satellite images. Watershed boundary of Shikaripura taluk has been delineated from watershed map generated by KSRSAC (Karnataka State Remote Sensing Applications Center). Cartosat-DEM (Digital Elevation Model) data with 15m and 30m spatial resolution have been collected from Bhuvan web platform, the contour and slope map have been prepared from Cartosat DEM. Later from the DEM, slope, aspect, TIN, drainage and shaded relief maps have been generated to get the information on geomorphology of the study area. Morphometric characters such as stream order, stream length and stream network are extrcted from DEM (Digital Elevation Model) data using spatial analyst tool of Arc map. The various morphometric parameters such as Linear

Parameters, Areal Parameters, Shape, Aspect and Relief Features are all calculated based on the mathematical equations suggested by Strahler (1964), Horton.,(1945) and Schumm(1956). Landsat-7, of 1993 and Landsat 8 OLI data sets of 2009, 2018 and 2019 have been processed (noise removal, haze reduction) and the layers are stacked into a single multispectral image using ERDAS (Earth Resource Development Assessment System) software. Land use/ Land cover map has been prepared by using supervised image classification technique in ERDAS IMAGINE and GIS software. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data set has been used for the lineament extraction which has been carried out using PCI Geomatica software. Geology map of the study area has been generated by digitizing the geology map prepared by Geological Survey of India, whereas soil map has been generated from soil map prepared by KSRSAC. Secondary data like groundwater fluctuation level, yield, rainfall, hydrometerological data, crop distribution, crop yield etc. have been collected from various departments and these data are validated by conducting extensive field survey. Agroforestry suitability map is generated using primary and secondary data collected, suitability class maps have been generated up to three level three classes (High, Medium and Low) and suitable crop model have been suggested. After all these analysis, suitable action plans are suggested for sustainable water resource management for Shikarupura taluk.

6. Organization of chapters:

The present work has been carried out with the above mentioned objectives. The general introduction, analysis, description, and conclusion are provided in eight chapters. The following paragraphs briefly explain each chapter, content wise. Chapter 1 covers introduction about the study area i.e., Shikaripura taluk and literature reviews on watershed management. Chapter 2 covers, Morphometric analysis of Shikaripura taluk. Chapter 3 is a study on Morphotectonic analysis of Shikaripura taluk. Chapter 4 focuses on Hydro meterological analysis of Shikaripura taluk. Chapter 5. is on identification of groundwater potential zones. Chapter 6. covers the socio economic conditions of Shikaripura taluk. Chapter 7. focuses on identification of Agroforestry suitability classes for the Shikaripura taluk for conservation of water resource management. Chapter 8. explains how sustainable watershed management plans can be implemented for the study area. Chapter 9.is ono Summary and Conclusion

Chapter 1:

This chapter gives a complete introduction about watershed management. Importance of water, their losses, distribution and their conservation. RS and GIS techniques which can be effectively used to understand the problems of the study area. The chapter also gives introduction about Shikaripura taluk, water related problems, geology, soil, climate, drainage, materials and methods and literature review, Chapter also coves objectives and scope of the present study.

Chapter 2:

This chapter explains how to evaluate the morphometric parameters of the study area by performing the morphometric analysis using remote sensing and GIS technology. By evaluating the morphological parameters, the true condition of the topography of the study area can be determined. For the detailed morphometric study, the study area has been divided into three watersheds by considering the watersheds within the administrative boundary of Shikaripura taluk, using the delineated watershed map generated by KSRSAC. Direct measurements of basic parameters of the study area (eg: basin area, basin perimeter etc) are obtained directly from GIS software based on the boundary shape files. Other morphometric characters such as stream order, stream length and stream network are extracted from DEM (Digital Elevation Model) data using spatial analyst tool. The various morphometric parameters such as bifurcation ratio, stream frequency, drainage density, drainage texture, form factor, circulatory ratio, elongation ratio, length of overland flow, relief ratio, stream length ratio are all calculated based on the mathematical equations suggested by Strahler (1964), Horton (1945) and Schumm (1956). The morphometric parameters could be useful in the determination of the availability of the water along with their appropriate management. Hypsometric curves of the study area are obtained by using the hypsometric tool which is available as an ArcGIS extension. Hypsometric curves and integrals have been interpreted in terms of degree of basin dissection and relative landform age.

Chapter 3:

In this chapter studies are made to understand the influences of tectonic activities on geomorphology and the fluvial system of the study area. Cartosat-DEM data of 30m spatial resolution was collected from Bhuvan web platform and using Arc map 10.2, hill shaded images of the study area has been extracted. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data set was collected for the lineament extraction which has been carried out using PCI Geomatica software. Lineaments are extracted using the LINE (Lineament extraction) tool and the trend of the lineament distribution is observed more in NE-SW, NNW- SSE direction. Geomorphological classification indicates that the presence of structural hills and ridges showing the tectonic influence on the morphology whereas the denudational hills and the denudational slope classes emphasize the impact of the drainage system on the terrain. The drainage network of the area is extracted from the GIS platform, and majority of the drainage patterns are dendritic and parallel in nature. Drainage analysis indicates that the fluvial system is mainly influenced by the slope of the terrain and not by the lineament distribution of the area. The morphotectonic parameters of the area are calculated by using the mathematical expressions. The channel sinuosity value ranges from 1.02 to 1.78 shows that the major part of the river is slightly influenced by geological/ geographical factors displaying medium sinuosity, whereas the basin elongation ratio value shows inactivity of the tectonics in the region.

Chapter 4:

In this chapter main focus is given on hydrometerological parameters of the study area and their influence on the groundwater condition, how the analysis of the hydrometerology will help to understand the water condition as well. In the study area generally, the weather is hot and humid and relative humidity ranges up to 88% Groundwater Information Booklet, Shivamogga district Karnataka 2007. The evapotranspiration is usually high in the high altitude, high vegetated regions. Data of important hydrometeorological parameters such as rainfall, evaporation, temperature, wind speed and sunshine duration are collected from the

government departments and authorities and the climatic condition of the study area is analyzed by classifying the time period into four classes viz, Summer, South west Monsoon period, Post Monsoon and North East Monsoon period.` Analysis of rainfall distribution in Shikaripura depicted that every year rainfall distribution is not uniform. . From the correlation analysis between the hydrometeorological parameters and depth of ground water level the relationships between them are derived. The negative correlation is observed between the rainfall and depth of water level which indicated that rainfall is the main influential factor for the rise or fall of the ground water level. Similarly, increase in the evaporation can cause the increase in the depth of the ground water level (positive correlation between depth of ground water level and evaporation) is observed.

Chapter 5:

In this chapter ground water potential zones have been discussed in detail. Remote sensing and GIS techniques are considered as an efficient tool. The usage of RS and GIS technique allow us to evaluate multiple aspects related to groundwater and decision making can be done on the basis of collective information. The creation of the thematic maps is carried out on the basis of both remote sensing and ground station data on the GIS platform. The survey of India topographical maps on 1: 50,000 scale are utilized for the validation of the Land use and Land cover maps and extracting contour intervals. The Cartosat-1 DEM (Digital Elevation Model) data is obtained from NRSC Bhuvan web platform. Based on this slope map and the geomorphology map of the area have been extracted. Lineament existing within the boundary of the study area has been extracted from ASTER data and by using the extracted line feature lineament density map has been prepared in Arc Map 10.5 GIS platform. Landsat 8 multispectral layer stacked data is undergone geometric and radiometric image corrections and Land use/Land cover map is prepared by using supervised image classification technique in ERDAS IMAGINE and GIS software. Further, for the validation purpose the above Land use land cover map is compared with the standard thematic layers. Further, weighted overlay analysis is carried out by combining the individual thematic layers assigning the specific weightages depending on their influence on one over the other and by integrating various thematic layers like geology, geomorphology, Land use/ Land cover, slope, aspect etc.

groundwater potential zones map has been delineated. Later this layer has been compared with the groundwater data obtained from District groundwater office, Groundwater Directorate Shvamogga for the validation purpose. Geologically Shikaripura taluk, belongs to Dharwar super group of western dharwar craton and lineament distribution is observed throughout the region. The average elevation varies from 472 m to 897 m and highly elevated topography is observed in the southern and northeastern part. Shikaripura gets an annual rainfall of 750- 800 mm on an average, majority of them during south west monsoon. The soil coverage of the study area is majorly contributed by loamy and fine soil with the few rock outcrops. The major crops of the region are paddy, ragi, maize and few horticulture crops such as beetle nut. Geomorphologically, the region is covered by structural and denudational hills with the plain of pediments contributing about 15% of the region. The crop land in the region is supported by the water supply from the Anjanapura reservoir but predominantly depended on the south west monsoon and the land with scarcity of water are remained as the fallow land.

Chapter 6:

In this chapter socio economic condition of the Shikripura taluk has been dealt in detail. Shikaripura taluk lie in the eastern part of the Shivamogga district having vast stretches of plain lands with low and rising hillocks with low vegetation and comes under Southern transition zone. Shikaripura is the third highest populated taluk of Shivamogga district, consisting a population of 2,36,418 in 2015 and the projected population in 2020 increased 2,46,301. The population of Shikaripura taluk is distributed between the towns and the villages but the villages hold more population compare to the town. The population in the villages are mainly dependent on the agriculture for their source of income whereas business and some marginal works are the source of income for the people in the town. The agricultural sector in this region mainly influenced by the south west monsoon and the agricultural activity is at its peak during this period. The dug wells, tube wells and the reservoir water become the sources to obtain the second crop. The crops of cereals cover the major part of the agricultural and by considering the area of coverage, few commercial crops like cotton, sugarcane etc. are also grown in small proportion. But the usage of chemical fertilizers is very high compared to the other taluks of Shivamoga hence there is always the chance of loss of soil fertility, water pollution in the region. The water availability from the various sources for agricultural and domestic uses are less (due to the high demand) hence the water gap in Shikaripura taluk is highest compared to the other taluks of Shivamogga district and the prediction for the year 2020 is also depicting

the same result. So, conservation and proper utilization of the water resource in a sustainable manner is become the fundamental solution for all the socio- economic problems that may arise due to the improper availability of water in the region.

Chapter 7:

In this chapter identification of Agroforestry suitability classes in the Shikaripura taluk for conservation of water resource management has been carried out . Agroforestry is a collective name for land use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (agricultural crops, pastures, etc.) or livestock in a spatial arrangement, a rotation or both. Shikaripura taluk boundary in shape file format has been obtained from Karnataka Geographical Information System (KGIS) portal developed by KSRSAC, which includes taluk, village and hobli boundary in shape file format. Thematic maps are generated by utilizing the spatial and non-spatial data using Arc Map 10.5 and WGS (World Geodetic System) 1984 is used as the coordinate system.

Collective use of Remote sensing and GIS with the available secondary and ground level data, integrated study has been carried out by mainly considering the crops for which agroforestry models are applied. Initially, the crop land data has been examined and further nutrient availability regions and agroforestry suitability classes are derived.

Potentially contributing factors towards agroforestry are considered and agroforestry suitability class map has been prepared by considering the amount of influence of each factor. Factors such as nutrient availability, slope, wetness index, rainfall and elevation are considered and the weight matrix are assigned based on their influence (Ahmad et al., 2017). Weights and ranks are assigned for each of the thematic maps based on the pair wise comparison. Collectively with the help of spatial analyst tool in Arc map 10.5. This approach has helped in assessing the land suitability for 22 crops in Syria (Ahmad et al., 2017). Agroforestry suitability classes of good, moderate and poor are generated using overlay analysis. Validation of the generated classes are carried out by visiting to the study region and observed the places which come under the suitability class of good are well suited for the application of agroforestry models. Agroforestry suitable class stimulation results showed that Kumudvati watershed covers the

large percentage of area of Shikaripura taluk but the large percentage of high suitable area is observed in northern Dandavati watershed. Hilly regions of the southern portion are not favorable for implementation of agroforestry. Three tier agricultural model for paddy is very much suitable for large paddy growing southern regions of Shikaripura. Denudational hills of the northern portion will be best suitable with sapota and teak based agro-system which is also commercially beneficial for the farmers. Tamarind based horticultural system will be beneficial for the less irrigated semi dry lands where rain is the only source of water for the plant growth. Crop land development with horticultural crops can be flexible by considering ground level situations and further qualitative and quantitative studies need to be performed by locally available suitable plant species

Chapter 8:

In this chapter the sustainable watershed management plans has been suggested for Shikaripura taluk. The watershed development plan can be implemented in the watershed area, to increase the groundwater level (by recharging the aquifers), identification of suitable recharge structures is carried out by studying various factor like geology, geomorphology, soil, crop yield, crop distribution, influences of tectonic activity etc. including extensive field study. Identified Sustainable Agroforestry for Conservation of water Resources By using Remote Sensing and GIS for Shikaripura Taluk. This technique can reduce the poverty and land degradation, improve food security and mitigate the climate change. Appropriate usage of these resource can help to improve the socio economic conditions of the people.

Chapter 9:

In this chapter Overall Summary and Conclusions have been provided. The research demonstrates systematic methods for evaluating and monitoring the Shikaripura taluk natural resources. The study also shows how effective Remote Sensing and GIS technologies are in the management of natural resources.

List of Publications

Papers Published in International Journals

1. Bhavya P and H. Gangadhara Bhat (January/2021) Morphometric Analysis of Watersheds in Shikaripura taluk, Shimogga District, Karnataka, Using Remote Sensing and GIS, Journal of Applied Science and Computations Volume VIII, ISSN NO: 0022-1945
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3. Pooja shree B.P and Bhavya P, 2016. Determination of Infiltration Rate of Soils using Double Ring Infiltrometer – Study of Soil Characteristics of Kundapura, Udupi Dist. International Journal for Scientific Research & Development, Volume 2 Issue 10 – OCTOBER 2016.

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